New construction of water wells with glass beads

Productivities and savings potentials

Since late 2007, glass beads were used as a replacement for gravel as filter pack material. The initial point was the poor quality of the available natural sands and gravels which causes a lot of disadvantages in relation to glass beads in terms of form, stability and other criteria [1]. The inferior breaking resistance of gravel resulted in irreversible clogging of the annuluswhich can only be compensated by complete renovations. The life cycle of a well is thereby considerably reduced. The quality and state of the other components would have allowed flawless operation for an additional 10 to 20 years.

In 2009, DIN filter gravels and glass beads were tested for their mechanical properties. Glass beads proved to be superior in all parameters tested [5]. In 2011, there were comprehensive comparative studies on the hydrologic and hydrodynamic characteristics together with the performance in the development process. Also here the glass beads turned out to be superior to than filter gravel [6]. Table 1 shows a brief contrast of the materials „glass beads and sand“.

Though the long-term performance records of wells finished with glass beads currently don’t exist, the benefits of glass beads can be expected due to material and hydraulic properties. While the technical advantages of glass beads are unanimously accepted among experts, higher procurement prices of glass beads compared to filter packs from mineral materials are frequently cited as a disadvantage and an obstacle to their application. The material price alone is by far not sufficient to assess the total cost-effectiveness of a well.

Wells are investment assets with a long service life of more than 40 years. In addition to the investment costs, the operation and maintenance costs have to be analysed in order to get a general idea of cost-effectiveness.

The major effect of the operating costs has long been known to be a major factor in the cost-effectiveness of wells. For a comparative cost effectiveness study,at least the following cost aspects must be taken into account:

- Investment costs,
- Energy costs of groundwater con veyance,
- Costs for maintenance and service (here: Costs of rehabilitation measures).

Recently the aspects of „investment costs“ or added costs for the use of glass beads compared to gravel and „energy costs of groundwater conveyance“ have been studied for newly constructed wells.

In 2009/2010, three new wells were constructed at a well field replacing existing wells in close distance. The wells were equipped with continuous wire wraped screens and glass beads as filter pack. Two of these wells, wells „A“ and „B“, are included in the following assessments. Other comparative data are available from a water well of a steel millt in Southern Germany.

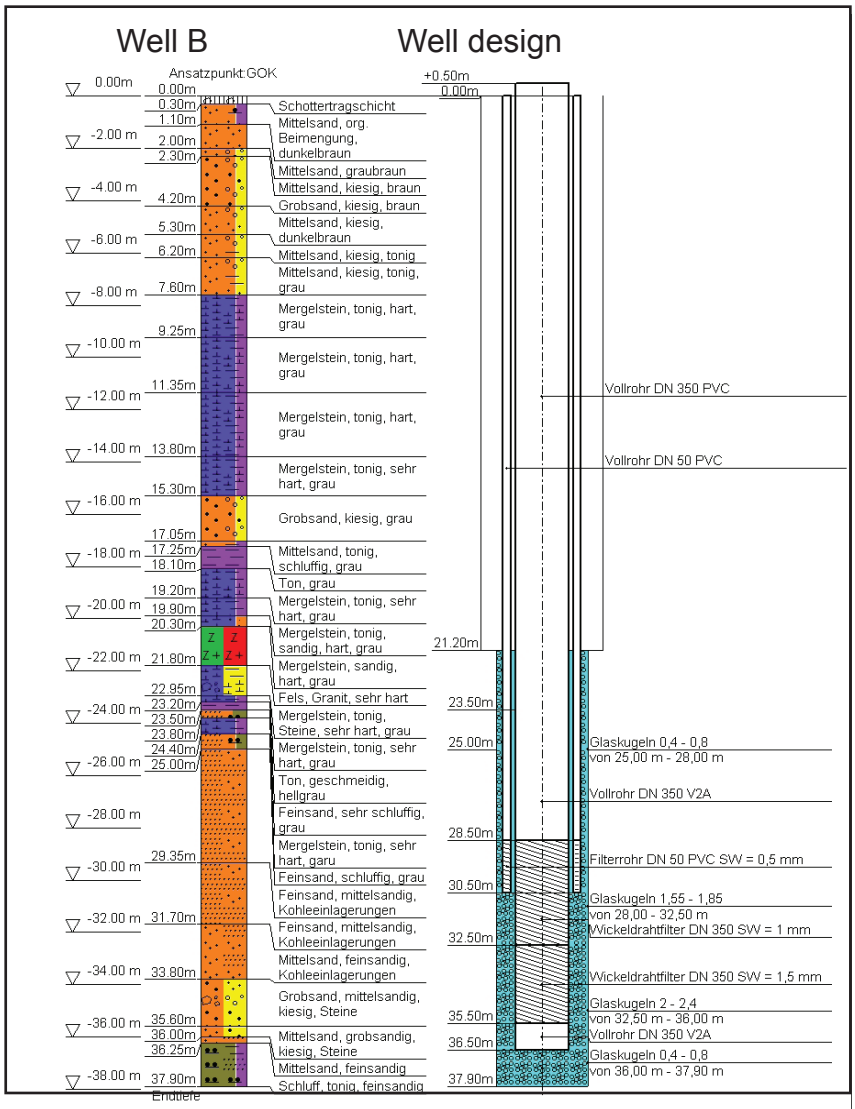

Figure. 1: Geology and instuction drawing of well "B" with glass beads

Table 1: Comparable contrast gravel/glass bearings in well construction

	Glass beads	Sand / Gravel
Percentage of undersize of material	+	-
Hydraulic properies	+	-
Mechanic properies	+	-
Bedding properies	+	-
Chemical resistance	+	-/+
Rehabilitation capability	+	-/+
Costs of material	-	+
Subsequent costs for development	+	-

In that well,in the original borehole the corroded copper screens and blanks were replaced with stainless steel continuous wire wrapped screens and stainless steel blanks. The annulus was refilled with glass beads. This well is listed as well „C“ in the assessment. The constructional drawings for wells „B“ and „C“ are shown in Figure 1 and 2 (Figure 3).

For these wells new data is available from pumping tests. Assessments of discharge flow and drawdown as well as specific capacities are shown in Table 2 (with: Q = discharge; s = drawdown; E = specific capacity). Significant boosts in capacity can be achieved in all wells (Figure 4).

In Table 3 savings of energy costs for conveyance resulted in the wells studied. The annual conveyance quantities were estimated in the calculations. The annual discharge quantities were estimated in the calculations.

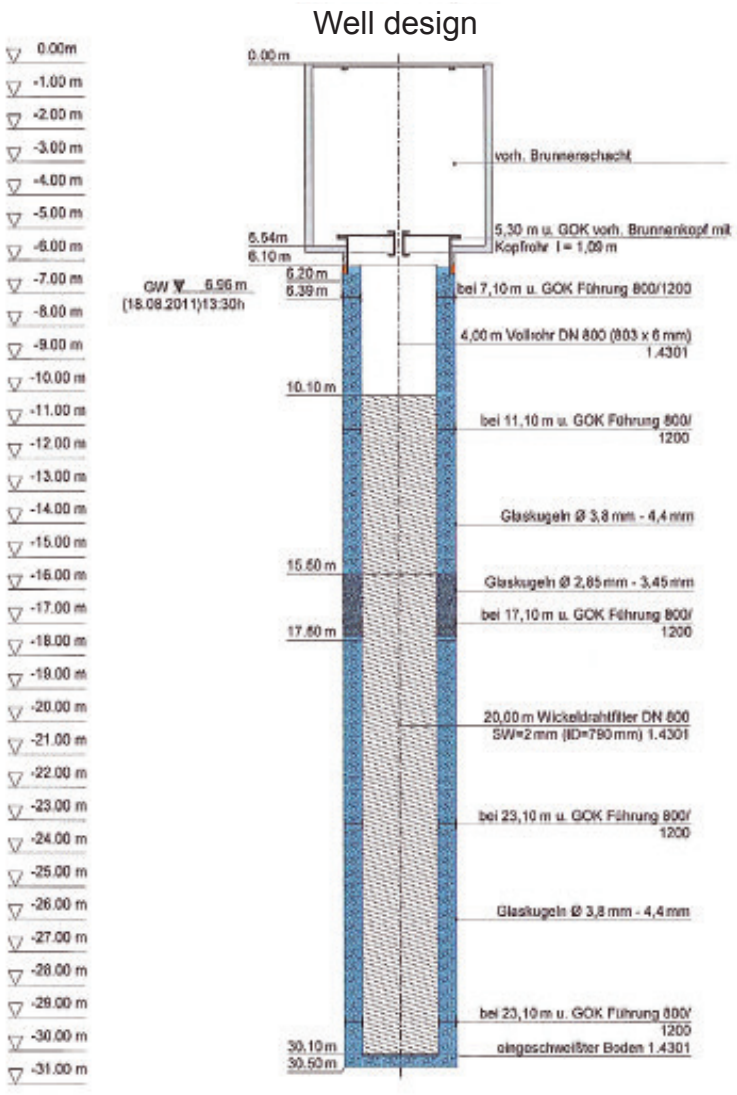

Figure. 1: Geology and construction drawings of well „B“ with glass beads

Table 2: Conveyance quantities and yields achieved

	Well expansion	Q1	s1	E1	Q2	s2	E2	Q3	s3	E3	E average	Performance increase by
		(m³/h)	(m)	(m³/h/m)	(m³/h)	(m)	(m³/h/m)	(m³/h)	(m)	(m³/h/m)	(m³/h/m)	
Well A	Stone mat/ gravel	15,60	3,13	4,98	33,80	6,98	4,84	61,70	9,90	6,23	5,4	
Well A new	Tinted glass	20,16	2,02	9,98	39,60	3,91	10,13	60,48	5,71	10,59	10,2	91,2%
Well B	Stpne mat/ gravel	11,84	1,11	10,67	28,10	3,77	7,45	42,48	5,63	7,55	8,6	
Well B new	Tinted glass	19,80	1,76	11,25	39,96	3,72	10,74	59,76	5,61	10,65	10,9	27,2%
Well C	Copper gauze	259,00	2,80	92,50	92,5							
Well C new	Copper gauze	288,00	070	411,43							411,4	344,8%

Table 3: Contrast of well capacities old/new and gravel / glass beads

Energy costs raw water conveyance							
		glass beads					
		Well A old	Well A new	Well B old	Well B new	Well C old	Well C new
Costs per kilowatt hour on average	(Euor/ KWh)	0,15	0,15	0,15	0,15	0,15	0,15
Discharge on average	(M≥/h)	60	60	60	60	200	200
Discharge (collection)	(M≥a)	500.000	500.000	500.000	500.000	1.800.000	1.800.000
Level of effectiveness (µ) on average	(%)	60%	60%	60%	60%	60%	60%
Special yield on average (according to available data)	(M≥h/m/)	**5,4**	**10,2**	**8,6**	**10,9**	**92,5**	**411,4**
Relative conveyance depths (only referring to strict reduction s)	(mWS)	11,2	5,9	7,0	5,5	2,2	0,5
Total of energy costs pumping	**(EUR/a)**	**3.818**	**1.997**	**2.389**	**1.878**	**2.651**	**596**
Savings	**(EUR/a)**		**1.821**		**511**		**2.055**

Cost comparisons for the use of gravel or glass beads were provided by the operators forwells „A“ and „C“. A cost contrast is shown in Table 4 and 5. The sole differences in annual costs from „saving energy costs“ and added costs „debt service“ for the selection of glass beads equals EUR 1,821 - 273 = EUR 1,548/a (savings potential well „A“) and 2,055-718= EUR 1,337/a (savings potential well „C“).

The extrapolation over an operating time of 40 years - presuming conditions remain the same - the resulting savings potential for well „A“ is approx. EUR 62,000 and for well „C“ approx EUR 53,000. Additional savings can be expected for glass bead filter packs due to minimized iron clogging tendencies and resulting bigger intervals of well rehabilitation. Observations of an old well approx.

four years old with glass bead filter pack in the Central Franconian sandstone Keuper have shown:

- Considerably less iron deposits in the annulus compared to wells with gravel pack,
- Minimal increase of filter resistance despite iron clogging,
- Easier removal of the deposits from the filter pack.

Table 4: Overview of total costs well “A”and “C’

		Well „A”		Well „C“	
“Partial trade		Filter pack with gravel	Filter pack with glass beads	Filter pack with gravel	Filter pack with glass beads
1.	Construction site set-up	EUR	EUR	EUR	EUR
2.	Drill	15,419	15,419	Individual costs not known	Individual costs not known
3.	Casing	13,581	13,581	Individual costs not known	Individual costs not known
4.	De-sanding and pump test	19,638	255,950	3,200	21,600
5.	Well completion work	8,632	8,632	3,300	1,485
6.	Inspections	31,502	31,502	Individual costs not known	Individual costs not known
Interim total 1 (Only well construction)		2,563	2,563	Individual costs not known	Individual costs not known
Interim total 1 (only well construction)		91,335	97,647	136,915	153,500
		100,0%	106,0%	100,0%	112,1%
Added costs			6,312		16,585

Table 5: Overrview of capital costs wells “A” and “C”

		Cost situation well “A”		Cost situation well “C”	
		Filter pack “Gravel”	Filter pack “Glass beads”	Filter pack “Gravel”	Filter pack “Glass beads”
Investment and capital costs					
Investment costs	(EUR)	91,355	97,647	136,915	153,500
Operation time	(a)	40	40	40	40
Annual capital costs	(EUR/a)	3.951	4.224	5.923	6.641
Added costs “capiitalised”	(EUR/a)		273		

Of importance here is the continuous monitoring of well productivities and the amount and costs of rehabilitation measures in order to update the well performance in a technical and financial sense. Finally, it should be noted that new wells equipped with a natural gravel pack can also show increases in performance when they will be properly constructed and developed. This was not a subject of the study. Due to the inferior stability of gravel compared to glass beads (a initially mentioned) - over the entire life cycle of a well - the authors see considerable technical benefits for the use of glass beads, particularly in terms of performance in addition to the financial benefits presented.

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